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SUMMARY OF CURRENT PRE-CAMBRIAN NORTH AMERICAN LITERATURE.

Gibson² gives a summary, from the reports of the Canadian Geological Survey, of the pre-Cambrian geology of the Hinterland of Ontario.

Coleman³ gives a summary of the geology of the Rainy Lake region. Following Lawson, the rocks are classified as follows:

Archean	{	Upper division.	<i>a.</i> Keewatin. (Huronian ?)
			<i>b.</i> Couthiching.
	{	Lower division.	Laurentian.

The Laurentian rocks consist chiefly of granite-gneisses, with subordinate quantities of granite and syenite. The Couthiching consists of fine-grained mica-schists and mica-gneisses which show rapid changes in composition in passing from one layer to another, thus suggesting sedimentation. These rocks are usually sharply separated from the Laurentian, but at Rice Bay the writer found himself in doubt as to the classification. The Couthiching series is regarded as a metamorphosed sedimentary one. As to the source of the material there is no very definite information, unless certain gneisses in Sand Island river having layers differing sharply in composition be looked upon as remnants of an original Laurentian floor. The Keewatin is a series of eruptive and fragmental rocks of great thickness and variety, consisting broadly of a lower division of basic eruptives and volcanic ashes, and an upper acid division. The bulk of the lower basic portion consists of diabases, with some gabbros and anorthosites, and apparently some diorites. Porphyroids are also present. The schistose members, often interbedded with the massive altered eruptives, near the contact with the

¹ Continued from p. 372, Vol. IV., JOURNAL OF GEOLOGY.

² The Hinterland of Ontario, by T. W. GIBSON. Fourth Rept. Ontario Bureau of Mines, 1894, Sec. III, part on pp. 124, 125. Toronto, 1895.

³ Gold in Ontario: Its Associated Rocks and Minerals, by A. P. COLE. Fourth Rept. Ontario Bureau of Mines, 1894, Sec. II, pp. 35-100. Accompanied by two geological maps of parts of the Rainy River district. Toronto, 1895.

Laurentian are chiefly hornblende-schists, but in other localities are chlorite-schists. Between these two are numerous transitions. Graywackes occur at several localities, and agglomerates and conglomerates are plentiful. The upper acid division includes felsites, sericite-schists, and quartz-porphyrries. These are apparently younger than the green schists and massive rocks of the Keewatin, but the two divisions are conformable, as is also the whole of the Keewatin to the Coutchiching. The rocks included in the Laurentian are, for the most part at least, intrusive in the Coutchiching and Keewatin. In the Keewatin are various intrusive granite areas. Cutting all of the previous series are dike rocks, which may be divided into an acid division, including granite and pegmatite, and a basic division, including diabase and quartz-diabase.

Many details are given as to particular occurrences of the various rock series. The occurrence of gold in Ontario is described, and incidentally the rock succession in the Hastings district is summarized.

Winchell and Grant¹ give a preliminary account of the Rainy Lake gold region. Following Lawson, the rocks there found are separated into four distinct groups. Beginning with the lowest these are: (1) Laurentian, composed of granites and granitoid gneisses and allied rocks; (2) Coutchiching, composed of mica-schists grading into fine-grained gneisses; (3) Keewatin, composed of hornblendic, greenish, and sericitic schists, conglomerates, graywackes, etc.; (4) Diabase dikes, more recent than and cutting all the others. The Coutchiching mica-schists have in many places rapid alternations in bands from an inch to several feet in width of slightly different mineralogical composition, structure, or color. The position of these bands gives the strike and dip of the rock, and when they are lacking the schistose structure is taken as giving the strike and dip, as this seems to be parallel with the banding when the two are seen together. On account of basal conglomerate beds in places in the Keewatin resting on the Coutchiching, while an unconformity between the two is not proven, it seems quite probable.

COMMENTS.

The banding of the Coutchiching mica-schists in many places described by Coleman, Winchell, and Grant is just such as has been

¹ Preliminary Report on the Rainy Lake Gold Region, by H. V. WINCHELL and U. S. GRANT. 23d Ann. Rept. Geol. and Nat. Hist. Sur. of Minn., for 1894, Part II, 1895, pp. 36-105.

ascribed to igneous rocks in other localities, and it yet remains to be proved that the series is sedimentary. Even if sedimentary, no satisfactory evidence is given that either the schistosity or banding corresponds with bedding. Using the classification of the United States Geological Survey, the Keewatin or a part of it would be regarded as Huronian, and the Coutchiching or a part of it would be regarded as Archean. It is rather probable that in the Thunder Bay district of Ontario and in northeastern Minnesota parts of two series have been included under each of these terms.

Smyth and Finlay¹ describe the western part of the Vermilion range. The sedimentary rocks fall into two divisions. The older is a fragmental slate formation, while the younger is an iron-bearing formation lithologically identical with certain phases of the lower iron-bearing formation of the Marquette district. To all appearances it is devoid of clastic material. It is believed, from analogies with other iron-bearing districts of the Lake Superior region, that the jasper of the Vermilion district is derived from a cherty iron carbonate or from a glauconitic greensand, or both. However, as the jasper is a final product of the alterations, it is not possible to show this.

Intrusive igneous rocks are very abundant, cutting or being interleaved with the sedimentary rocks in masses running from the thickness of a knife blade to those 100 feet across. In quantity the igneous rocks exceed, perhaps several times the sedimentary rocks. The oldest igneous rocks are greenstones. These vary from massive to schistose, and into conglomerate-breccias. The acid rocks were intruded later than the basic rocks. They were originally for the most part quartz-porphyrries, but these have been extensively changed to sericite-schists and conglomerate-breccias, and to rocks intermediate between these and the original form. Within the larger masses of the igneous rocks, both basic and acid, are frequently included fragments from both the slate and iron formations, from those of small size to masses more than 100 feet long.

The conglomerate-breccias are of dynamic origin. The first step in the development of the breccias was the formation of two intersecting sets of planes of fracture, dividing the originally massive rocks

¹The Geological Structure of the Western Part of the Vermilion Range, Minn., by H. L. SMYTH and J. RALPH FINLAY. *Trans. Am. Inst. of Min. Engineers*, Vol. XXV, 1895, pp. 595-645.

into roughly rhomboidal blocks. Their further development depended on continued movement between these blocks under pressure, which resulted in enlarging the shearing zones at the surfaces of contact, and rounding the angles. The slate and jasper inclusions originally plucked off from the rocks which the porphyries and greenstones invaded, shared, of course, the subsequent history of their captors. The fact that the jasper inclusions are frequently rounded, while those of slate are not, is explained by the difference in the elasticity of the two rocks. The slate inclusions readily yielded and finally took a permanent set under the deforming forces, while the harder and more rigid jasper, in fragments of limited size and diverse orientation, behaved like the enclosing porphyry. The boundaries of the inclusions were generally the surfaces along which rupture took place, although, as has already been said, jasper in a few instances is found partly held in porphyry inclusions.

As to structure, the main slate area is anticlinal; both north and south of this area the jasper succeeds the slates. The southern jasper continues in a complex syncline, and south of this is found the northern limb of another anticline of slates, the southern limb not being exposed. Still farther south is the jasper of Lee and Tower Hills, which appears to form the southern and western edges of a complex syncline. All of these folds pitch toward the east.

The ore deposits are found to conform in occurrence to the laws worked out by Van Hise in reference to other districts of the Lake Superior region; that is, (1) they occur for the most part in pitching troughs with impervious basements. Usually this impervious basement is one or more of the different varieties of the eruptive rocks. (2) They are secondary concentrations produced by downward percolating waters, the silica being leached out and the iron ore deposited.

Smyth, (H. L.),¹ describes a quartzite tongue in the jasper at Republic. This tongue branches from the main mass of quartzite, and after continuing nearly parallel with it for a long distance, tapers to a point toward the north in a mass of specular jasper. The quartzite tongue includes between itself and the main quartzite a similar jasper tongue, which starts in the north from the jasper, and tapers to a point toward the south in the quartzite, the two tongues interlocking. These

¹ The Quartzite Tongue at Republic, Michigan, by H. L. SMYTH. JOURNAL OF GEOLOGY, Vol. II, 1894, pp. 680-691.

unusual relations are explained as due to faulting approximately parallel to the fold which occurred during the folding of the series.

Van Hise¹ describes the rocks of the Marquette district as constituting a great synclinorium. The axial planes of the minor folds on the sides dip toward the center of the synclinorium, thus resembling the fan structure of the Alps; but there is the great difference that the major fold is a synclinorium rather than an anticlinorium. This kind of fold may be called the Marquette type.

Clements² describes the volcanic rocks of the Michigamme district of Michigan. The succession in the district from the base up is (1) granite and gneiss, cut by basic dikes; (2) quartzose limestone formation, with an estimated thickness of 1500 to 2000 feet; (3) a great series of volcanics, with an average thickness of about 3000 feet; (4) a set of sedimentaries consisting of quartzites, slates, and iron formation material. The volcanics include apobasalts, apo-andesites, and aporhyolites, each occurring both as lavas and as tuffs. The lavas are frequently amygdaloidal.

Smyth (H. L.),³ compares the Lower Menominee and Lower Marquette series in Michigan. The Lower Menominee series consists in ascending order of

1. A basal quartzite, rarely conglomeratic, having a thickness of 700 to 1000 feet.
2. A crystalline limestone, averaging 700 to 1000 feet in thickness.
3. Red, black, and green slates, not known to exceed 200 or 300 feet in thickness, and containing the iron formation that gives the rich ores of Iron Mountain and Norway. Toward the north the horizon of the slates is in part occupied by later eruptives, that rapidly increase in thickness and attain a maximum of nearly 2000 feet.
4. The Michigamme Mountain jasper. The least modified phase seems to be in part at least a sediment. The most highly altered kind is like the banded, specular jasper of Republic.

¹ Character of Folds in the Marquette Iron District, by C. H. VAN HISE. *Proc. Am. Assoc. for Adv. of Sci.*, for 42d Meeting, 1894, pp. 171. (Abstract.)

² The Volcanics of the Michigamme District of Michigan (preliminary), by J. MORGAN CLEMENTS. *JOURNAL OF GEOLOGY*, Vol. III, 1895, pp. 802-822.

³ Relations of the Lower Menominee and Lower Marquette Series of Michigan (preliminary), by H. L. SMYTH. *Am. Jour. Sci. (III)*, Vol. XLVII, 1894, pp. 216-223.

The Lower Marquette series in the western part of the Marquette area consists in ascending order of

1. A basal conglomerate, quartzite, quartz-schist—probably less than 100 feet.
2. An iron-bearing formation which may be divided into a lower actinolitic schist and an upper banded red jasper and specular hematite. The iron-bearing member has a maximum thickness of more than 1000 feet.

The magnetic jasper of Michigamme mountain by means of outcrops and magnetic work, has been traced within one and one-half to two miles of the iron-bearing formation of the Marquette series, and the two are regarded as equivalent. If this be true, the Lower Marquette quartzite may represent the lower quartzitic portion of the Michigamme jasper formation, in which case the whole of the Lower Marquette series would be represented by the highest member of the Lower Menominee.

The absence in the Marquette district of the equivalent of the great thickness of limestone, quartzite, and eruptives below the Michigamme jasper in the Menominee district is accounted for by supposing that the Marquette area was more elevated, and that the transgression of the ocean from the south reached the Marquette district when the lower portion of the Michigamme jasper was being deposited. If the above correlation be correct it further follows that the principal ore formation of the Menominee has no equivalent in the Marquette district.

The Mount Mesnard series of quartzite, limestone, and slates, as described by Wadsworth, in the eastern part of the Marquette area, between the Cascade range and Lake Superior, has many points of resemblance to that part of the Lower Menominee series below the Michigamme jasper. The age of the Mount Mesnard series is still in doubt, but if it should prove to underlie the Lower Marquette (Wadsworth's Republic formation), its position would probably indicate the limit of the old Marquette highland on the eastern side.

COMMENTS.

One point upon which additional evidence seems to be necessary is that the slates bearing iron ores in the Menominee district proper are really equivalent to the slates associated with eruptives farther north. If these are not equivalent, it is possible that the Michigamme

jasper and these iron-bearing slates are the equivalents of the iron-bearing formation and the quartzite below in the Marquette district. If the latter proves true the principal ore horizon of the Menominee may have an equivalent in the Marquette district.

Weidman¹ describes the igneous rocks of the Lower Narrows of the Baraboo River. These are in a belt from one-eighth to one-half mile wide, running for four miles in a direction east and west. Chemical and microscopical study shows this rock to be a quartz-keratophyre. It is shown to be a volcanic rock by its flowage structure, broken crystals, and by volcanic breccias. The rock has a schistosity parallel to the bedding of the quartzite. The quartz-keratophyre rests upon the topmost layer of quartzite, with a possible erosion interval. It has been folded with the quartzite, and like that rock rests unconformably below the undisturbed Cambrian.

Beyer* describes spotted slates associated with the Sioux quartzite series in the northeast corner of Minnehaha county, South Dakota. The quartzite here grades up into reddish slate, which in lithological character corresponds to the quartz-slate described by Irving and Van Hise in the Penokee series of Michigan and Wisconsin.

Bayley³ gives fully the field occurrences, relations, and petrography of the eruptive and sedimentary rocks of Pigeon Point. The oldest rocks are interbedded Animikie slates and quartzites. Cutting the Animikie rocks is an olivine-gabbro, which occupies all the higher portions of the point. It is in all probability the lower portion of a large dike, whose upper part has been removed by denudation. Between the gabbro and the bedded rocks in many places are successively a coarse-grained red rock, a fine-grained red rock (quartz-keratophyre) and a series of contact rocks. The main masses of the keratophyre occupy a position between the Animikie sedimentaries

¹ On the Quartz Keratophyre and Associated Rocks of the North Range of the Baraboo Bluffs, by SAMUEL WEIDMAN. Bull. Univ. of Wis., Sci. Ser., Vol. I, 1895, pp. 35-56, pls. 1-3.

*The Spotted Slates Associated with the Sioux Quartzite. by S. W. BEYER. Johns Hopkins Univ. Circulars, No. 121, 1895, p. 10.

³The Eruptive and Sedimentary Rocks on Pigeon Point, Minn., and their contact phenomena, by W. S. BAYLEY. Bull. 109, U. S. G. S., with maps and plates. Washington, 1893.

and the gabbro. This rock has all the characteristics of an eruptive younger than the gabbro. The coarse-grained rocks between the gabbro and the keratophyre are intermediate in character between the two, and grade into them. They are therefore regarded as a contact product formed by the intermingling of the gabbro and keratophyre magmas. The keratophyre also apparently grades into the Animikie slates and quartzites, there being three zones showing different grades of alteration of the sedimentary rocks, due to the contact with the igneous rock.

From the peculiar relations it is regarded as probable that the keratophyre is of contact origin; that is, it was produced by the fusion of the slates and quartzites of the Animikie through the action upon them of the gabbro. The magma thus formed then acted in all respects like any intrusive magma. It penetrated the surrounding rocks in the form of dikes, and solidified as a soda-granite under certain circumstances, and under others as a quartz keratophyre. Cutting all of the previously mentioned rocks are diabase dikes.

Bayley¹ gives a detailed petrographical study of the basic, massive rocks of the Lake Superior region and especially of the great gabbro of northeastern Minnesota. The normal phase of the gabbro is found to have a typical granitic structure and to differ essentially from all of the basic intrusive rocks of the Animikie series and from all other Keweenawan basic rocks, none of which have a distinctly granitic structure. Upon the border of the main mass of gabbro are peculiar rocks which are interlaminated with quartzose bands. These are shown to be but peripheral phases of the gabbro. It is concluded that further field work will probably show that the gabbro is either a batholite, well toward the base of the Keweenawan series, or that it is a eroded mass upon top of which the later Keweenawan beds have been deposited.

Elftman² finds that the great gabbro of northeastern Minnesota has a rude arrangement of the rock in parallel layers similar to the

¹ The Basic Massive Rocks of the Lake Superior Region, by W. S. BAYLEY. *JOURN. OF GEOL.*, Vol. I, 1893, pp. 433-456, 587-596, 688-716; Vol. II, 1894, pp. 814-825; Vol. III, 1895, pp. 1-20.

² Notes upon the Bedded and Banded Structures of the Gabbro and upon an Area of Troctolyte, by A. H. ELFTMAN, 23d Ann. Rep. Geol. and Nat. Hist. Sur. of Minn. for 1894, part XII, 1895, pp. 224-230.

layers of sedimentary rocks. This structure usually dips to the south. It does not depend upon the differentiation of the mineral components of the rocks, but seemingly is due to secondary causes which acted upon the rock after it had solidified. This sheeted structure is a common phenomenon along the northern limits of the mass. The gabbro has also a banded structure due to the parallel arrangement of the mineral constituents. The bands are not regularly arranged, appearing and disappearing in a manner which shows them to be not independent of the secondary causes. This structure is present to a marked degree in the central portion of the gabbro.

Large feldspar masses occur in the gabbro in the southeastern parts of T. 61 N., Rs. 10 W. and 11 W. The mass in the latter township has a marked banding. The line of division between the feldspar masses and the normal rock is sharp in the field and in the hand specimen. Both are, however, regarded as differentiations from the same magma.

In the southern part of T. 62 N., R. 10 W., the eastern part of T. 61 N., R. 11 W., the greater part of T. 61 N., R. 10 W., and in adjacent townships is a considerable area of dark, reddish-colored olivine-gabbro or troctolyte, which has both a sheeted and banded appearance. This rock and the normal gabbro have not been seen in contact, but wherever they closely approach each other, often within a few feet, both preserve their characteristic structure, and there is no sign of the transition of the one into the other. The olivine rock appears to be above the ordinary gabbro.

Hubbard¹ gives two geological cross-sections of the Keweenaw series in the vicinity of the Calumet and Hecla and the Tamarack mines. The strata here consist of interstratified traps, amygdaloids, sandstones, and conglomerates. Deep in the series there is less amygdaloid, and it is suggested that the amygdaloids are largely pseudo-amygdaloidal, their development being dependent upon sub-surface weathering. It is found that the conglomerates approach each other in passing from the north toward the south, due to the thinning of the igneous beds. The Eastern sandstone, somewhat remote from the line of junction with the Keweenaw series, has at places a dip toward the traps as high as 10° or 12°. At Lake Linden this formation is

¹Two New Geological Cross-sections of Keweenaw Point, by L. L. HUBBARD. Proceedings of the L. S. Mining Inst., Vol. II, 1894, pp. 79-96.

shown by boring to be at least 1500 feet thick, and to consist of red sandstone with several streaks of marl. The likeness of this sandstone to the upper Keweenawan sandstone, the faulting along or near the contact line of the two formations, and the thinning of the traps and amygdaloids in passing toward the Eastern sandstone, seem to strongly favor the theory that the two formations are of the same age.

COMMENTS.

The question of the relations of the Eastern sandstone to the Keweenawan is too difficult a one to discuss here, but it may be said that it is the reviewer's opinion that the evidence presented is far too slight for so important a conclusion. For a comprehensive discussion of the question the reader is referred to Bulletin 23 of the United States Geological Survey.

Winchell,¹ discusses the origin of the Archean greenstones. The great bulk of them are pyroclastic. They were distributed and somewhat stratified by the waters of the ocean into which the material fell. As evidence of their arrangement by water is their very general stratiform structure, which can only be explained by the action of water. This structure stands vertical or nearly so. These greenstones constitute a distinct terrane, forming the latest portion of the Keewatin, at the top of the Fundamental Complex of the Lake Superior region. Below the greenstones are found chloritic slates and schists, chloritic schists, clay-slates, graywackes, conglomerates, quartzites, novaculites, and jaspilites. The thickness of the greenstones in Minnesota exceeds that of any other Archean terrane. The Keewatin passes gradually down into crystalline mica-schists or hornblende-schists, and finally into acid gneiss.

COMMENTS.

In certain parts of the Lake Superior region the greenstones are predominantly pyroclastic, and in other parts are predominately intrusive or extrusive lavas. Not only is this so, but within the same series in the same district the basic igneous rocks in one part are mainly tuffs, and in other parts are almost wholly massive.

I would altogether dissent from the conclusion that the banding of the igneous rocks alone is evidence of their arrangement by water. In

¹ The Origin of the Archean Greenstones, by N. H. WINCHELL. 23d Ann. Rep. Geol. & Nat. Hist. Sur. of Minn., for 1894, Part II, 1895, pp. 4-35.

certain areas and series the banded pyroclastics have been largely deposited in water ; in other areas and series there is no evidence whatever of such deposition.

The pyroclastics south of Lake Superior, instead of belonging to a single terrane, belong to at least three, distinct, unconformable series. From the base up these are the Archean or Fundamental Complex, the Lower Huronian, and the Upper Huronian. Furthermore, while year after year evidence has been sought upon this point, we have been wholly unable to show that any of the Archean tuffs of the south shore were deposited in water. However, the tuffs of the Lower Huronian and the Upper Huronian have been largely deposited in water, and between ordinary sedimentary rocks showing little or no tufaceous material and ordinary tuffs which give no evidence of water arrangement, there are all gradations.

Winchell¹ reviews the stratigraphy of the Lake Superior region. In reference to the Keweenaw series he reaches the following conclusions: (1) The eruptive rocks which in Michigan, Wisconsin, and Minnesota have been included in the Keweenaw, consists of two widely differing series of widely separated ages. Included in these pre-Keweenaw eruptives are the great gabbro of Minnesota and the red rocks such as those at the Palisades and at Pigeon Point. This eruptive period is called the Animikie revolution. (2) This period was followed by a long erosion interval, during which were deposited the Sioux quartzites of Dakota, the New Ulm quartzites of Minnesota, the Baraboo and Barron quartzites of Wisconsin, and the quartzites and conglomerates below the Keweenaw diabases in the Penokee district. In the New Ulm quartzites are found "taconite" jasper pebbles, and these are taken as evidence that this material was derived from the Animikie. (3) Following this conglomerate and quartzite is the Keweenaw eruptive age, which separates the Paradoxides horizon from the Dicelloccephalus horizon. (4) The Olenellus horizon is separated from the Paradoxides horizon by the disturbance that closed the Animikie.

The general succession for the Lake Superior region is given as follows:

¹Crucial Points in the Geology of the Lake Superior Region by N. H. WINCHELL, *Am. Geol.*, Vol. XV, 1895, pp. 153-162, 229-234, 295-304, 356-363, and Vol. XVI, 1895, pp. 12-20, 75-86, 150-162, 269-274, 331-337.

Upper Cambrian.		St. Croix. Eastern sandstone. Lake Superior sandstone. Nipigon formation. (The <i>Dicelloccephalus</i> — “ Potsdam ” of New York).	Progressive subsidence.
<i>Olenus zone.</i>			
Taconic (or Middle and Lower Cam- brian).	Keweenawan. <i>Paradoxides</i> <i>zone.</i>	Keweenawan. Traps and underlying Quartzite and Conglomerate. Potsdam at Potsdam, N. Y., and eastward to the Au Sable River.	
	Non-conformity.		
	Animikie. <i>Olenellus zone; Foraminifera.</i>	Animikie slates. Pewabic and Wauswaugoning quartzites. Penokee series. Mesabi iron range. Misquah hills. Gabbro and Anorthosite range. Norian. Upper Laurentian. Bohemian range and South Copper range in Michigan. Minong range, Isle Royal.	
The Great Non-Conformity.			
Archean.	Ontarian.	Keewatin.	
		Coutchiching.	
	Laurentian.		

The following general conclusions are reached as to the Lake Superior region and other parts of the United States :

The rocks of the Cortland series (the clastics), of the original Taconic area, and of the upper series of the Adirondacks are of the same age, *i. e.*, Taconic or Lower Cambrian.

The basic rocks of the Norian or Upper Laurentian system of Canada are of the same age as the gabbros of the Adirondacks.

The Taconic in America embraces all the strata containing any known fossils older than those in the *Dicelloccephalus* or Upper Cambrian. It is separated from the Archean by a profound unconformity.

The Animikie strata in Minnesota and in general the upper iron-

bearing series of the Lake Superior region are of the age of the Taconic.

The Taconic age is represented in the Lake Superior basin, as in New England and Newfoundland, by a great series of quartzites and slates, and a few limestones.

Those rocks which have been described and mapped as Keweenawan embrace three eruptive systems, separable by two erosion intervals marked by basal conglomerates and by faunal differences, viz., the eruptives of the Animikie revolution, those of the Keweenawan proper, and the eruptives of the regions of Thunder Bay and Black Bay.

It is added as a corollary to the foregoing that the ocean which covered the spot where North America was to exist was subject to forces which acted simultaneously over a very wide area, producing oceanic deposits of like nature and of like succession in widely separated regions; and, again, that some other widely operating forces caused the simultaneous elevation, depression, and finally the breaking of the earth's crust and the escape of vast quantities of basic rock at various points far distant from one another.

COMMENTS.

Professor Irving¹ was perfectly well aware that under the term Keweenawan, as used by him, there are included two great divisions of rocks. The coarse gabbros of Wisconsin and Minnesota, cut by red rocks, are so sharply separated from the remainder of the Keweenawan that he was tempted to separate the two and place the former in the Huronian. Between the two he says there is a certain sort of unconformity. His belief in the difference between the two is further emphasized by his map of northeastern Minnesota, on which the two were for the first time given separate colors. The difference, therefore, between Professor Irving² and Professor Winchell upon the first conclusion is mainly one of nomenclature.

The reviewer either dissents from each of the remaining conclusions of Professor Winchell, or holds that we have no definite knowledge in reference to them.

C. R. VAN HISE.

¹The Copper-bearing Rocks of Lake Superior, by R. D. IRVING, Mon. V. U. S. G. S., pp. 144-145, 155-156. 1883.

²Classification of Early Cambrian and pre-Cambrian Formations, by R. D. IRVING. 7th Ann. Rep., U. S. G. S., Pl. XLI. 1885-6.